

**Contribution to the present status of *Spiochaetopterus costarum*:
description of *Spiochaetopterus koreana*, a new species of
Chaetopteridae (Polychaeta) from the West Coast of Korea**

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Abstract.—Examination of a collection of Chaetopteridae (Annelida: Polychaeta) from the Yellow Sea (West coast of South Korea) led to the erection of a new species, *Spiochaetopterus koreana*. Its main characteristics are the presence of a ventral shield in two contrasting black and white parts, visible through the transparent wall of the tube; a pair of black spots at the base of the A2 setae; B1 and B2 with unilobed neuropodia; the hindmost ventral secretion area extending well beyond the setae of A9; upper oblique plan of the specialized seta on A4, with two sub-equal lobes. The erection of this new species confirms, in spite of the probable existence of a long larval life which is accepted as a means of countering local differentiation, the extensive differentiation within this genus.

Many marine species with wide distributions, the so-called cosmopolitan species, are sibling species-complexes and are, in fact, more subdivided than originally thought (Hilbish 1996; Knowlton 1993). The broad geographic distribution attributed to many species is often a taxonomic artifact and needs to be reassessed. This general statement is particularly applicable to the polychaetous annelids (Mackie & Pleijel, 1995; Williams, 1984), and more specifically to the Chaetopteridae, (genus *Spiochaetopterus* and species *S. costarum*). Reported throughout the world's oceans, *S. costarum* was at first believed to be a cosmopolitan species (Okuda 1935; Day, 1967; Blake, 1996). However, Bhaud (1998a & 1998b) showed that different species of *Spiochaetopterus* are found on the western and eastern coasts of the North Atlantic Ocean despite the probable ability of larvae to disseminate throughout the Atlantic Ocean. Since then, the same author has been very attentive to reports of *Spiochaetopterus* under the species name of *S. costarum* in di-

verse parts of the world's oceans and outside its actual specific area. Consequently, recent descriptions of new species of *Spiochaetopterus* in areas as different as Brazilian coasts (Bhaud & Petti 2001), Persian Gulf (Bhaud & Martin 2002) and the Yellow Sea (the present paper), are explained.

Materials and Methods

Specimens were collected on the west and south coasts of South Korea in three groups of stations: areas A, B and C (Fig. 1). The type locality is Station 7 (Fig. 1) in the Sorae Bight, 14 m depth relative to low tide (37°20'20 N; 126°36'80 E). The stations of the three areas have similar characteristics; they all lie in sheltered zones and the bottom is a silty-sand sediment. The total number in the collection was 82, distributed as follows: area A: 35 specimens sampled in Nov 1998 and Feb 1999, area B: 9 specimens sampled in Sep 1999 and Area C: 38 specimens sampled in Sep 1999.

Observations were made in several ways.

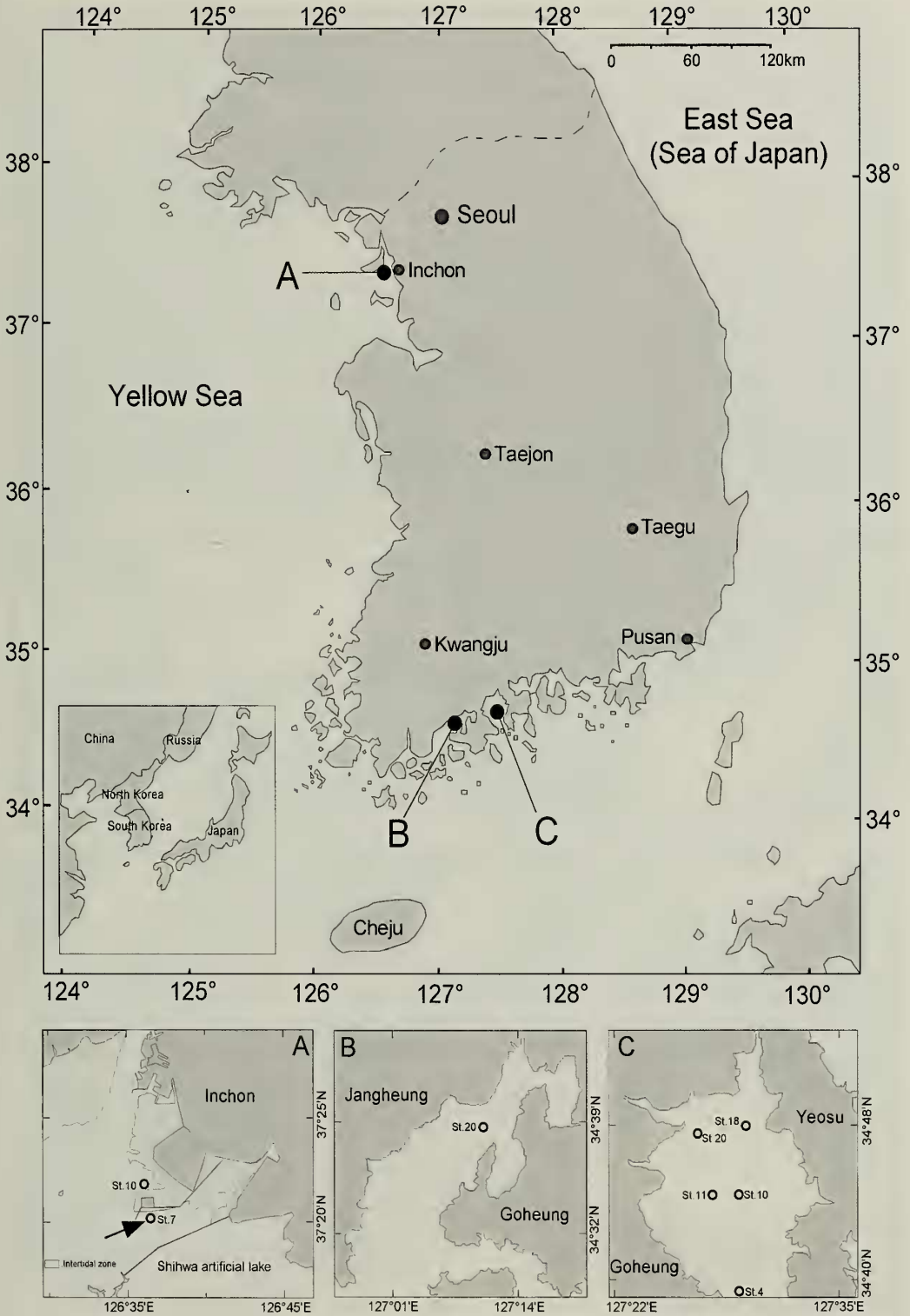


Fig. 1. Map of the collection areas. The principal map indicates the location of three districts, A, B and C of the Korean coasts, in which specimens were collected. In the lower part, for each district, detail of location of stations is given. In district A, the arrow indicates the type locality.

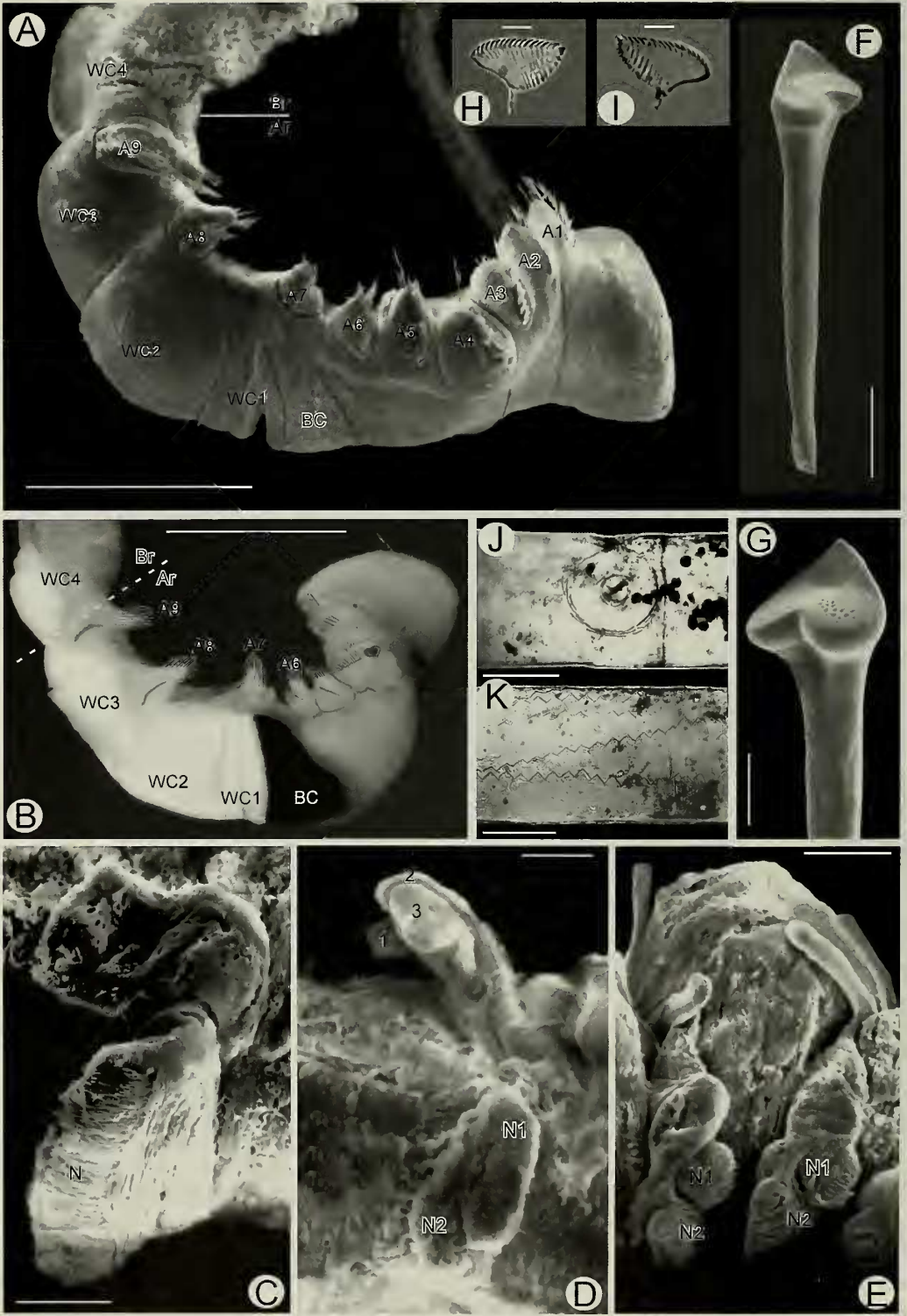


Fig. 2. A-E, orientation of the animal is the same: anterior part on the right side. A. Anterior part (A region) observed with a scanning electron microscope. Because color cannot be shown the different parts identified on

For observations by SEM, setae were dissected from preserved specimens, immersed in KOH (diluted 1:2) for 15 min, rinsed three times in distilled water, 30 min each, processed through a graded alcohol series and stored in 70% ethanol until observation. Immediately prior to viewing in a Hitachi S.520 SEM (University of Perpignan, Centre of Electron Microscopy), setae were transferred to absolute alcohol, air-dried, attached to a stub and coated with gold palladium. Fragments of tube were observed by a Diaplan Leitz light microscope; photographs were taken with a Leica-Wild MPS 32.

Following the suggestion by Crossland (1904), the anterior, middle and posterior body regions of chaetopterides are herein designated A, B, and C, respectively; A4 thus refers to setigerous segment 4 in region A, B2 to setigerous segment 2 in region B, etc.

Systematics

Family Chaetopteridae

Spiochaetopterus Sars, 1856

Spiochaetopterus koreana, new species

Type material.—Holotype: National Museum of Natural History, Paris N° MNHN-POLY 70. Paratypes: National Museum of Natural History, Paris N° MNHN-POLY 71a and 71b. Other specimens were deposited in the personal collections of the authors. Photographs of specimens fixed in alcohol were kept by the authors.

Diagnosis.—This is a large, oculate *Spio-*

chaetopterus species. Each A4 parapodium has a single modified, enlarged cutting seta at the distal end. This obliquely truncated distal end is approximately heart-shaped in end view, with two equally developed lobes. The shaft of the seta has a subcircular cross section throughout its length. Region A has 9 setigerous segments ($n = 37$). At the level of setal bundles 6 and 7 of region A, the ventral face exhibits a shield with two contrasting parts. The hindmost ventral secretion area extends well beyond the setae of A9. Region B has more than 2 segments (maximum observed: 12). The neuropodia on the first two segments have only one lobe. The tube is unbranched, smooth, transparent, without distinct articulations by with areas regularly disposed with folded tube wall. Tube diameter: 1200 μm .

Description.—Body size and colour: The anterior part reached 6 mm in length. All the A segments plus 10 B segments extended to 17 mm. The general color on preserved specimens was pink for the anterior region, and creamy white for the middle part. Fragments of the posterior region, were partly greenish brown. The ventral part carried a contrasting black and white shield.

Region A: On all examined specimens ($n = 37$), 9 setigerous segments were present in region A. The horseshoe-shaped peristomium allowed sufficient room for the blunt prostomium whose front edge was almost flat. There were two black ocular spots anterior to the tentacles on the lateral

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the ventral face have been delimited by a thin line. As for the whole family, the letters A, B and C indicate the three regions of the body. B. Anterior part (A region) photographed with a dissecting microscope in order to observe the contrasting ventral shields. C. Structure of neuropodia (N) in B1 and B2 segments formed with one lobe. D. Structure of all notopodia formed with three lobes (1–3); structure of neuropodia in B3 segment and following segments formed with two lobes N1 and N2. E. Structure of noto and neuropodia in a segment of C region. F, G, Specialized seta of A4 segment. H, I. Uncini observed in B1 segment. J, K. Structure of the tube with an articulation, a transversal septum applied on the tube wall and eggs (J), with longitudinal serration (K). Abbreviations: Ar, A region; Br, B region; A1 to A9, setigerous segments 1 to 9 of A region; BC: black crescent; WC1 to WC4, white crescents 1 to 4. Regularly arranged secretory pores occupy the first part WC1. Scale bars: A, B = 860 μm ; C–F = 100 μm ; G = 50 μm ; H, I = 4 μm ; J, K = 600 μm .

edge of the prostomium. In all the examined specimens, a long shield in two contrasting colors characterized the ventral surface: black for the anterior part and white for the posterior one (Fig. 2A, B). The medio-ventral part of the short black crescent-shaped fore-shield (BC or black crescent on Fig. 2A, B) extended between the bundles on A6 and A7 (Fig. 2B). The two points of the crescent extended posterior to the A7 bundles. The crescent was thus oblique. Alongside the ventral posterior border of the black shield, the white shield, on setigerous segments 8 and 9, reached well beyond the A9 setal bundle. This white shield was heterogeneous: a narrow crescent just after the A7 setae (WC1 or white crescent 1) and easily identified by the presence of regularly arranged oval pores, a homogeneous white area ending at the middle of the A8 setae (WC2) and a white area punctuated by brown spots on the posterior part (WC3 and WC4) with a marked constriction at the level of the A9 setal bundle. The region anterior to the black crescent was brick coloured; it was delimited at its forward end by a transverse crescent at the level of segment 1 and two longitudinal curved lines from the A1 setae to the A7 setae where they come into oblique contact with both black and white crescents. These lines were deepest around A4. Ventral to them the tegument was brown to dark pink and dorsal to them it was pale pink. On several specimens, the color of the ventral face, and ventrally to the longitudinal lines was not homogeneous: there was a wide, transverse dark pink belt at the level of A2 and A3. A black spot immediately ventral to each A2 seta constituted the last specific criterion. On some preserved specimens these two black spots were linked together by a thin transverse black ventral line.

Region B: It had a maximum of 12 setigerous segments ($n = 14$), with uniramous neuropodia on B1 and B2, and biramous neuropodia on the remaining setigerous segments. The notopodia, as in many other species, carried a bilobed Y-shaped inner

part and a large unilobed outer part (total: three lobes; Fig. 2D). The insertion point of this lobe was far from the internal lobes but close to the main neuropodial lobe. The base of these notopodia was preceded by a pronounced, raised transverse ring on the first B segments, diminishing on later segments. Neuropodia had only one lobe on segments 1 and 2 (Fig. 2C), and 2 lobes, always vertically extended, on the other segments (Fig. 2D). As in other species (Bhaud & Petti 2001) the uncial plates of the neuropodial lobes were inserted in such a way that their respective sets of teeth faced each other, pointing posteriorly on the anterior lobe (progressive position) and anteriorly on the posterior lobe (retrogressive position). Two brick-red lines extended the length of the ventral face of region A and then disappeared around B1 or B2. A ciliated groove, with a pink band on each side, extended the length of the dorsal face.

Region C was incomplete (maximum of eight segments on specimens with A+B regions); some fragments of C region observed with pygidium. The structures of noto- and neuropodia were typical for the genus (Fig. 2E): notopodia were cylindrical, not inflated or slightly inflated at the distal part, without or with one seta projecting outside the terminal lobe. These short notopodia were inserted at the bottom of the intersegmental constrictions. Neuropodia were composed of two fleshy lobes with uncini: a short upper, anteriorly oriented lobe, and a vertically extended, lower, posteriorly oriented lobe. These lobes were escorted with prominent tegumentary crests. Pygidium without special characteristics; a dorsal notch separated two lateral lobes.

The morphology of the A4 specialized seta was specific. Setigerous segment A4 carried a single modified seta on each ramus, straw-colored to yellowish, with a swollen, obliquely truncated distal end. The upper oblique plane was cordate with the horizontal ventral edge hollowed out. The two lobes of the upper oblique plane were equal or subequal. This weak asymmetry

of lobes was only observed when the seta is viewed face on. The overhang of the ventral edge was clearly marked. The cross section of the shaft was regularly sub-circular with no longitudinal furrow (Fig. 2F, G) on the dorsal side as well as the ventral side.

Uncini were particularly small (length: 20 μm), triangular in shape; the small teeth were clearly individualized at 100 magnification. Nine teeth were counted on the straight median section of 10 μm (Fig. 2H, I).

The tube unbranched, smooth and transparent, without distinct articulations reached a diameter of 1200 μm . The transparent wall had regular folded areas, not immediately visible (Fig. 2J). A comparison with other described species (Bhaud 1998a) indicated that the number of layers secreted by the ventral shield of area A was limited. The difference was that in the present case, this thin wall was observed all along the collected tubes (8 cm), and not only on the 2–3 cm protruding out of the sediment. This tube was probably the upper part of a longer tube because we never observed the whole body. Septa were present and had a single perforation. A transverse serration at the tube opening, as described in Bhaud et al. (1994) and Bhaud (1998a), and other transverse serrations further posteriorly on the tube, representing previous tube openings, were also observed. A longitudinal rupture, which extends lengthwise, following approximately the same meridian, was also present (Fig. 2K). It showed one or several series of parallel indentations, which always occurred in pairs because they were the result of the rupture of some or all of the wall layers, related to body growth in the width of the tube.

Etymology.—This species name is taken from the country name Korea plus the Latin suffix *-anus* (=belonging to)

Ecology.—In the collection area, the bottom is a silty-sand sediment. However, the proportion of silt and sand was variable in time. At station 10 of district A, an increase in the silt fraction was observed from 1996

to 1997 with a simultaneous increase in the number of tubes per m^2 . The proportion of sand, silt and clay varied over the same period from 64, 33 and 3 % respectively (in 1996) to 34, 58 and 8 % respectively (in 1997). In the same time, the tube density (N/m^2) increased from 3 to 74 (Lee 1999). Proportion of silt and number of individuals, depended on the current flow rate which, if low, increased particle deposition and decreased larval dispersion. During the period 1996–1997 the dynamics of both currents and sediments were altered by the building of several jetties and the dredging of a large coastal area, thus explaining the variation in the number of specimens.

Variation in space was also observed. In this collection the tube structure varied with the district where the specimen was found. In C11 (district C, station 11 in Fig.1) the tubes were all straw-yellow but much darker than in A10 (district A, station 10 in Fig.1). This difference correlated with the number of layers forming the tube wall, was probably linked to the very high sedimentation in station A10 correlated with the proximity of the Yellow Sea and of the estuary of the near river. This sedimentation forced the animals to construct their tubes continually as they were covered over. In station C11, a zone characterized by a lower sedimentation, tube extension could be slower which allowed the animal to construct a tube consisting of a higher number of mucopolysaccharide layers.

Sea surface temperature varied from -0.5°C in February to $+28.5^\circ\text{C}$ in August (Koh et al 1997, Park & Park 2000).

For conditions of reproduction, some specimens displayed mature segments in region B. In addition, eggs were observed in one tube. The spherical shape reached a diameter of 76–80 μm .

Discussion

This new species has already been observed in the studied area under different designations: *Spiochaetopterus sp* (Hong &

Lee 1983), *Telepsavus costarum* (Paik 1989) *Spiochaetopterus costarum* (Lee 1999; Lim & Hong 1997; Lim et al 1992). In the nearby Japanese area, before the work of Nishi et al (1999) which began the revision of Chaetopteridae in the area, only 2 *Spiochaetopterus* were known at the subspecies level: *S. costarum okudai* and *S. costarum costarum* reported by Nishi (1996) and Nishi & Arai (1996). These subspecies have now been promoted to the level of species: *S. okudai* and *S. okinawaensis* and they have been joined by the new species *S. sesokoensis* (Nishi & Bhaud 2000). These Japanese species are different from the one described in the present note. The two equal or subequal lobes of the upper oblique plane of the specialized seta differentiate the Korean species from the two Japanese species: *S. okinawaensis* and *S. sesokoensis* Nishi & Bhaud 2000. In addition, this new species is differentiated from *S. sagamiensis* and *S. okudai* by the clear division of the upper oblique plane of the specialized seta into two lobes. A provisional summary for the Pacific Ocean includes the following species: *S. pottsi* (E. Berkeley 1927), *S. monroi* (Monro 1933), *S. okudai* (Okudai 1935); *S. okinawaensis* Nishi & Bhaud 2000, *S. sesokoensis* Nishi & Bhaud, 2000, *S. sagamiensis* Nishi et al, 1999. A total of 6 species with, in addition, the one described in the present paper. In the Atlantic Ocean, five species were redefined (Bhaud 1998a): *S. typicus* Sars 1856, *S. bergensis* Gitay 1969, *S. costarum* (Claparède 1870), *S. oculatus* Webster 1879, and *S. solitarius* (Rioja 1917) and a new species recently described *S. nonatoi* (Bhaud & Petti 2001).

As a consequence of this high number of species, the question arises: how may the relationship between the presence of a long planktonic stage in the life cycle and the relatively small area of each species be understood? (cf for instance Scheltema 1971, 1974). Either the planktonic larval life is not as long as is thought, or there is no causal link between larval dispersion and

specific area. This latter hypothesis is probably correct (Bhaud 2000). The putative cosmopolitanism of *S. costarum* was the result of both inadequate morphological examination and the use of questionable ecological arguments linked to larval dispersal. Thus, larval dispersal was often used to justify a wide geographic distribution for a species. It was also said that the gene flux inside the area counteracted any differentiation that might have arisen. However, Vrba (1983) argued that genetic mixing does not contribute as much to the integrity of a species as selection in a particular environment. Selection is a first rate cohesive force. Mobility acts by reducing a population's chances of isolating itself, but it also acts by augmenting the probability of encountering a new environment that is not necessarily favorable. In this case, the more the individuals are mobile, the greater is the likelihood that they will experience a new selection factor, and speciation becomes more probable.

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